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AN ENERGY EFFICIENT CLUSTER FORMATION PROTOCOL FOR MULTI-HOP WIRELESS SENSOR NETWORKS USING FUZZY LOGIC

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ABSTRACT

Life time performance/enhancement plays always a vital role as most of the WSN's operate in the unwanted environment where people can't access and monitor the things in practically. Clustering is one of the very flexible and powerful procedures that provokes the system performance or operation in an identical method to attain the machine scalability, decrease energy consumption and attain prolonged network life. To fix this matter, now a days a lot of researchers being endeavoured that the propositions of several different algorithms. Even though most of suggested algorithms overload the cluster head (CH) in the time of clustering formation. To conquer this issue many investigators developed a brilliant idea of fuzzy logic (FL) which applies to WSN for making a decision. These calculations focus on stature and ability of CH that can be accommodate, flexible and skilful enough to share the load among the sensor nodes which fortifies the network life time. Now particularly we suggested that a sophisticated and publication algorithm EECFP-FL which use FIS from the procedure for clustering formation. We affirm it by using many parameters in cluster formation that reduces energy intake. We emphasise our strategy with the recognizable protocols like LEACH, HEED, PSO and BFA-PSO to demonstrate that having a multi parameter FIS that will boost the network life considerably.

KEYWORDS: Cluster Head, Fuzzy Logic, LEACH & Energy Consumption

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Original Article

1. INTRODUCTION

WSN's that have consisted of a small type of sensor nodes. The sensors are very small in size (depends on application) and less-complex devices. These sensor nodes sense the signal and procure the information from its neighbourhood nodes. Actually, according to communication part in a WSN it can be done either single hop or multiple hop. In a single hop communication only one hop can be used to transmit a signal or information/data from sensor node to Sink/BS whereas in a multi-hop communication two or more hops can be used to pass the information/data a cluster head to destination. In Multi-hop communication the data/info will not transfer directly it can divide as a Cluster thereby. Under clustering method sensor passes the data/info to the cluster head. By eventually Cluster-head collage the information from various nodes in a cluster and pass the info/data to concern BS/Sink. Actually, the routing techniques are classified into three types such as FLAT, HIERARCHICAL and LOCATION -BASED.

LEACH Protocol the system is partitioned to a bunch. At Every bunch one node chosen as a Cluster-Head On the grounds of chance. Actually, Leach Protocol has categorized in to two stages Like Set-Up Stage and

Steady-State Phase. At Set-Up stage sensor nodes wish to become a Is greater than compared to the threshold value. Each of the info/data has passed out of the sensor nodes into the cluster-head and at finally Cluster-Head collects the data/info which has passed into the BS/Sink.

HEED (Hybrid Energy- Efficient Distributed Clustering) Protocol will use two types of parameters which are 1) Residual Energy. 2) Communication Cost. Actually, the functionality of HEED is classified into several phases. At the initialize phases the node reveals its probability to be a Cluster-Head in which the sensor selects their probabilities between 0 and 1. At main phases one of the nodes becomes a tentative node whereas rest of them as members in the cluster. At Final phase the node which has a least communication cost becomes CH.

Buddha Singh et al indicated a PSO method of maximizing the positioning of this group head at reduced cost [1]. In reality, a semi-distributed approach/method was used and implemented an algorithm within the cluster rather than the BS/Sink. The residual energy, Distance and Head count are the factors might be used since the selection criteria to the Goal -Function. By applying this PSO Algorithm which reinforce the Life phase of sensor networks with the support of Development of a Centralized, Energy-Aware cluster-based protocols and in this manner which employs a high-energy node for a CH and construct clusters which are continuously positioned across the entire sensor-filed [4]. PSO has a range of the characteristics like simplicity, fast convergence and memorizing at the position and rate data/info in the parade of growth to indicate a mobile beacon node route accessibility system [5].

Vipin Pal et al proposed a genetic algorithm which aids A load balanced system The CH selects based on its residual electricity and additionally protects trade-off of Intra audience communication distance. Genetic Algorithm helps to improve the total quantity of audience heads. The Fuzzy multiple attribute decision (MADM) Strategy or plan was used for choosing the viewer heads that helps to improve or increase the neighbourhood.

The remainder of the paper is organised as follows. Section II summarizes the related work and Section III presents the Radio Model of WSN. Section IV suggested version. Section V simulation and outcomes accompanied by the conclusion in Section VI.

2. RELATED WORK

Fundamentally, LEACH is a real clustering protocol for WSN. It's by far the most obvious protocol for improving the general life time of this system and lower the total energy intake by the system [11]. In fact, the performance in LEACH is split into a number of those rounds. Every round retains a setup stage where every sensor node selects a random number between 1 and 0 to choose whether it becomes CH or not. If the number selected by a specific node is significantly less compared to threshold-value T(n), then the node becomes a CH for the present round. We can calculate /measure T(n) from the below Formula 1.

$$T(n) = \begin{cases} \dfrac{p}{1 - p \times \left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The above equation defines,

Where

p is the anticipated percentage of audience heads,

r is the round number, and

G *is the pair of nodes which haven't been a CH in the previous 1/p rounds.*

The Sensor Node if it will become a CH it moves an advertising message to everyone their detector nodes about its designation for a CH. Depending upon the signal power the detector nodes specify to which audience they belonged to. This info/data is delivered to its CH by employing CSMA/MAC protocol. When the CH and its members have been finalized then the CH generates TDMA schedule and also the exact same content will be transmitted to all its associates. Each one the events/trails take an area in Set-Up stage. In the Steady-State-Phase, the Information -Transmission occurs according to the TDMA Program, the sensor-nodes moves their data/info to its CH from the allotted time-slots. In a specific time period, whenever one detector -node passing the information, the remaining nodes radio could be turned down to resultants for energy conserving. When the CH has the info/data from its associates then it (information) is processed and gathered is sent into the SINK/BS

HEED-Clustering Algorithm that leads a number of benefits better than LEACH Protocol. Really, The CH nodes aren't chosen as randomly. The CH has to select on the Floor of 2 parameters 1. The Sensor-Node's Residual Energy 2. Later the operation Classifies into 3 stages Like 1. Initialization Phase 2. Repetition Phase 3. Finalization Phase. At the Initialization Stage each and each sensor-node sets the Probability as CH-prob of being a CH on the floor of Residual Energy and Maximum Energy.

$$CH_{prob} = C_{prob} * \frac{E_{res}}{E_{max}} \tag{2}$$

Where,

C_{prob}=initial fraction of CHs among all sensors

E_{res}=Current energy in the sensor

E_{max}=maximum energy

In the repetition stage the sensor-node receives the CH to that it transmits the information with minimal energy. In case a sensor-node not receives some material in CH, it chooses itself as among the CH. It transmits a message to it all intimates (neighbours) about exactly the same. The sensor-node sends two kinds of status messages. One is tentative standing in which the sensor-node will end up undependable CH with less than 1 and finally the sensor-node becomes closing status i.e. it turns into a permanent CH once it reaches 1. The sensor -node transmits its info/data into the CH and CH transmits an aggregate information into the BS/SINK on Multi-Hop communicating. PSO program a Centralized-Head is going to be utilised to keep the attributes/features of their member nodes for each and every production. To have the ability to attain the requirement, a randomly selected Cluster-Assistant (nCA) allocates in every Cluster to maintain the job of every detector along with the other sensor features (characteristics) such as Position, Energy, Number of CH a global Greatest and additional PSO parameter values behave like the regional Processing Centre to a Cluster. At the beginning of each round of CH choice each one the sensor-nodes in around the Cluster provides their very first location, energy quantity and volume of nodes present to the Assistant-Node [1].

From the Global-Best variant of PSO, the place/position where the Node "I" has its lowest cost stores as p-best-id and g-best-id that is the best Node in the total Hunt Space. In each iteration "k", rate "Vi" and set "Xi" are updated by using

(1) and (2) and profits until a suitable g-best is accomplished or a predetermined number of iterations "k" max is reached/arrived.

$$Vi = Vi - 1 + c1 * rand() * (pbest - Xi) + c2 * rand() * (gbest - Xi) \quad (3)$$

$$Xi = Xi\text{-}1 + Vi$$

Where

Vi - the Node's Velocity.

By initially the values of the Velocity are randomly produced within the range (-Vm,Vm)

Vm - Max Value that can be allocated to any Vi

Xi - Nodes Current Position

pbest & gbest - Particles and Swarm Values

r and () -Random Number Between 0 and 1

c1 & c2 - Learning Factors that governs the cognition and social components.

BFA-PSO Method defines the optimized location of these randomly deployed nodes in the search-space that overlooks the fitness-function [6]. The Fitness-Function derives which choice would be better in comparison to others and it is instrumental in elucidating the direction along with dimension of the Velocity Vector in each iteration. From the E-Coli germs mechanism of detecting the regions with increased nutrient value and preventing expelling noxious areas, an optimisation strategy that simulates the process that termed as the Bacterial Foraging Algorithm evolves [4]. Chemotaxis is a foraging behaviour that retains the custom of the optimization. The rate of this node movement controllers from the chemotactic measure dimensions, C. A change from the direction of motion /alternating while the move at precisely the exact same way is swimming. In fact, the path of motion after tumble/flip is going to be depending upon the place of each node are upgraded by using (3) and (4) at PSO.

As discussed above, LEACH, HEED, PSO and BFA-PSO protocol. However, these protocols are used to assist to select the cluster head whereas our algorithm, EECFP-FL, uses fuzzy logic for cluster formation.

3. RADIO MODEL of WSN

The energy is dispersed (dissipate) through the transmission system, the energy optimization procedure has employed. The power model considered in our work is known from [14] as shown in Figure 1.

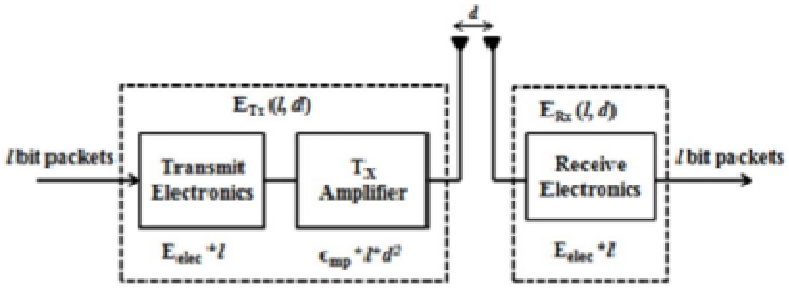

Figure 1: Energy Radio Model

The transmitter scatters capability to run the radio electronics and a power amplifier whereas the recipient frees electricity to radio electronics. The number of energy consumption is crucial for l bits to visit a space (from the transmitter to the receiver) via reception and transmission is given in equation 4.

$$E_{Tx}(l,d) = E_{Tx-elec}(l) + E_{Tx-amp}(l,d) = \begin{cases} l*E_{elec} + l*\varepsilon_{fs}*d^2 if d < d_0; \\ l*E_{elec} + l*\varepsilon_{mp}*d^4 if d \geq d_0; \end{cases} \quad (4)$$

Where

E_{elec} - The energy dissipated per bit to run the transmitter or the receiver circuit.

ε_{fs} & **ε_{mp}** - The characteristics of the transmitter amplifier. Specifically, **ε_{fs}** will be used for free space and **ε_{mp}** for multipath.

The Space between transmitter and Receiver is less than the threshold value d0, the free space variant (d2 power decrease) will be used. The multipath fading channel variant (d4 power decrease) is used. Power control can be used to undo this decrease by appropriately adjusting the power amplifier.

E_{Rx} - The amount of energy consumption to receive l bit of data is shown in the equation (5) and equation (6) represents the threshold value **d_0** that is the ratio of **ε_{fs}** and **ε_{mp}**.

$$E_{Rx}(l) = E_{elec} * l \quad (5)$$

$$d_0 = \sqrt{\epsilon_{fs}/\epsilon_{mp}} \quad (6)$$

The distance between the two nodes that is shown with d variable is computed through the equation (7).

$$d = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2} \quad (7)$$

In equation (7) (X_A,Y_A) is the position of node A in the network and (X_B,Y_B) is the position of node B in the network.

4. PROPOSED MODEL

4.1. System Assumption

In My suggested variant, sensor-nodes are considered as set up uniformly /

Homogeneously to monitor the surroundings consistently.

- All these sensor nodes are considered static such as BS/Sink
- That all the sensor-nodes could have equal energy.
- The standby CH (SB-CH) is preferred previously Level of the series (neighboring BS) for sending the material right into BS at Case of Any energy drop out occurs.

4.2. Proposed Algorithm

Step 1: Initialization

- Let N sensor-nodes are being distributed randomly over MxM region where “k” clusters are presumed.

- N- sensor nodes are divided into different levels.

Step 2: Cluster Head (CH) Selection

- Elect the CH at each level on the basis of Fuzzy logic Model.
- Apply Fuzzy if-then-else rule to make elected the CH.

Step 3: Cluster Formation

- All the elected CH's send advertisement info/data for cluster formation
- All the CH collects the data from its cluster members and aggregate the collected info/data.

Step 4: Transfer Data

- Transfer the Information from 1 CH to another CH till it reaches into the BS/SINK but Info Must come from the Upper level.
- One Sensor-node that has greater energy is chosen as stand-alone (SB-CH) Near the BS to restart the connectivity when any failure happens at last CH (the rationale is that CH nearer to BS absorbs more energy)
- Compute the Neighbour Cluster Heads, if any CH dies, Re-elect CH from Neighbour Cluster Heads.

4.3. Fuzzy Logic Model

Actually, the concept of Fuzzy Logic depends upon four steps such as,

- fuzzification,
- rule evaluation,
- aggregation, and
- defuzzification.

These four steps are used in FIS to compute the chance values as follows.

Step 1: Input of Crisp Value and Fuzzification

First, we forward our inputs (crisp values) represent our parameters like

- Remaining battery power,
- Distance to the BS, and
- Concentration to our FIS.

Based on those 3 sharp worth, we derive the value of this membership function, that's that the inter-section stage of the worth of our parameters together with the level of their membership function.

Step 2: Rule Evaluation

After conclusion of this fuzzification step we forward the membership values obtained to our IF-THEN principles to ascertain our newest fuzzy output set. Our fuzzy IF-THEN rules will have several inputs as well as also the Fuzzy-

Operator (AND) that only chooses the minimal of our three membership worth, will be make used to receive a single amount.

Step 3: Aggregation of the Rule Outputs

The aggregation is a practice of the marriage of all of the outputs got from using all principles (27 principles in our FIS version). Since we've employed an OR Fuzzy Logic operator, we collect all of our principles. The OR operator that selects the highest of our rule test values to generate the new aggregate fuzzy set which we utilize in the following step.

Step 4: Defuzzification

The final step is that the defuzzification, where we obtained our physical fitness value. We've employed the Mamdani method to measure the implication worth, along with the defuzzification way to discover the CH election exercise worth to create a bunch formation.

The very first two factors are for remaining/residual battery power is significantly less, moderate and large. The next linguistic variables for space to BS/Sink are accepted as near, far and farther. The next geometric factors for immersion are thought to be low, moderate and high. Concentration that describes the number of sensor nodes happen to be available in that specific area.

Within our system we have used 27 principles in Fuzzy Inference technique. These principles are implemented on three fuzzy input factors for example 1) remaining/residual battery power, 2) Distance to BS and 3) concentration, and the output variable is Fitness-Value. The output Fitness- Value which consist of 7 membership functions those are

- Very wea
- Little weak
- Weak
- Little medium
- Medium
- High medium
- Little strong, Strong, and Very Strong

Based on the Fitness-Value, CH is selected, using Mamdani's Fuzzy rule. The fuzzy rules and value of Fitness-Value is portrayed in below table

Table 1

Remaining Battery Power	Distance to BS	Concentration	Fitness Value
Low	Farthest	Low	very weak
Low	Farthest	Medium	weak
Low	Farthest	High	little weak
Low	Far	Low	weak
Low	Far	Medium	little weak
Low	Far	High	little medium
Low	Near	Low	little weak
Low	Near	Medium	little medium

Table 1: Contd.,			
Low	Near	High	medium
Medium	Farthest	Low	little weak
Medium	Farthest	Medium	little medium
Medium	Farthest	High	medium
Medium	Far	Low	little medium
Medium	Far	Medium	medium
Medium	Far	High	high medium
Medium	Near	Low	medium
Medium	Near	Medium	high medium
Medium	Near	High	little strong
High	Farthest	Low	medium
High	Farthest	Medium	high medium
High	Farthest	High	little strong
High	Far	Low	high medium
High	Far	Medium	little strong
High	Far	High	strong
High	Near	Low	little strong
High	Near	Medium	strong
High	Near	High	very strong

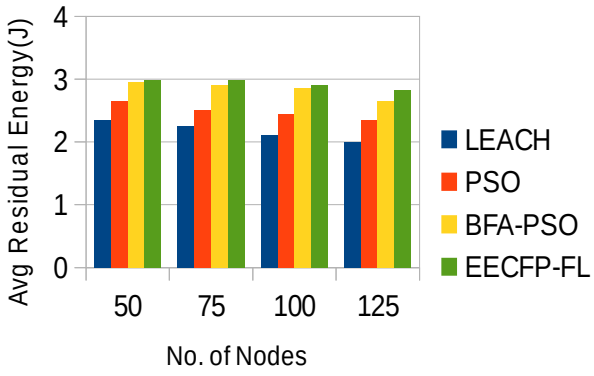

Figure 2

The following Performance Metrics have been analysed.

- No of Nodes Alive.
- Average Residual Energy
- No of Cluster Head Elected.
- Average Energy Consumption

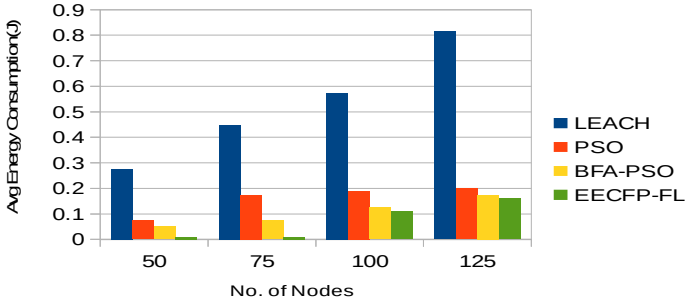

Figure 3

Average Remaining/Residual Energy with respect to the number of nodes are deployed. For every 25 nodes increase in the deployment, the average residual energy of the nodes in LEACH, HEED, PSO and BFA-PSO approach gets decreased remaining/residual energy. Our proposed algorithm EECFP-FL has been increased residual energy.

Energy Consumption with Regard to No. Of Nodes. For each increase of 25 nodes installation in LEACH, HEED, PSO and BFA-PSO implemented energy conscious clusters which create increase in energy intake when compared with our suggested EECFP-FL implemented clusters which create decrease in energy intake.

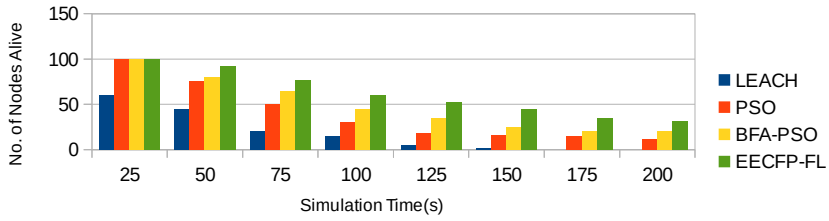

Figure 4

In above figure Number of nodes are being alive by diversifying simulation-time. The augment in simulation time the total number of nodes are alive on EECFP-FL performance is so good as compared to the rest of nodes on LEACH,PSO,BFA-PSO performance that resultants long standing of battery of whole network/long span of network lifetime.

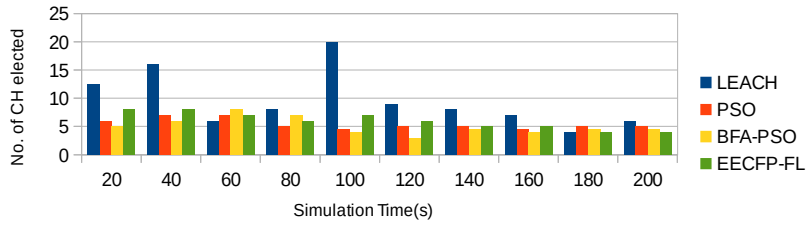

Figure 5

Actually, CH would be elected on the basis of simulation time but the EECFP-FL Approach affords more steadied number of CH's with long standing nodes as compared to rest of approaches such as LEACH, PSO, BFA-PSO.

CONCLUSIONS

The LEACH protocol is a really promising one and provides a chance to improve in a variety of areas of the communicating so the applicability of this protocol broadly extends. HEED clustering algorithm is a distributive clustering method that concentrate on electricity and communication cost concurrently. In precisely the exact same time, it may act as a pragmatic classification algorithm and it utilizes the residual power of their communication price to choose the best set since the cluster head nodes. In my job the whole sensor networking system was divided into a range of levels and in every level, using Fuzzy LOGIC the bunch head is chosen. In fact, there are 3 varieties of fuzzy descriptors like Distance to Base channel, Staying battery power and immersion that may be obtained in an account. Each cluster head sends the information until it arrives in the gate-way/base station/sink. The New found protocol uses the concept of fuzzy logic that manages real time issues more acutely than some of the probabilistic version. Nevertheless, multi-hop communication protocol provides a larger range for a bigger program. It finishes by simulation results that EECFP-FL provides better functionality/performance, such as scalability, residual energy, energy intake, better system lifetime time than LEACH only jump, HEED multi-hop protocol, PSO and BFA-PSO.

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